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New Records of *Hyachelia tortugae* Barnard, 1967, and *H. lowryi* Serejo and Sittrop, 2009 (Amphipoda: Gammaridea: Hyalidae), from Palmyra Atoll National Wildlife Refuge: Cooccurrence on Pacific Green Turtles (*Chelonia mydas*).

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ABSTRACT

Amphipods of the genus *Hyachelia* collected during an epibiont survey conducted over three years (2009, 2010, and 2011) at Palmyra Atoll are reported. Both known species, i.e., *Hyachelia tortugae* Barnard, 1967, and *Hyachelia lowryi* Serejo and Sittrop, 2009, were collected from Pacific green turtles, *Chelonia mydas* (Linnaeus). Given the increased awareness of epibionts and the desire of researchers to make positive identifications, figures of the diagnostic features of both amphipod species are presented. The significance of the cooccurrence of these two species on Pacific green turtles (*Chelonia mydas*) is discussed.

INTRODUCTION

The genus *Hyachelia* was established by Barnard (1967) based upon a single ectocommensal amphipod species, *Hyachelia tortugae*. Barnard noted that this “remarkable” species was the first record of a talitroidean amphipod living as an ectocommensal. These specimens were

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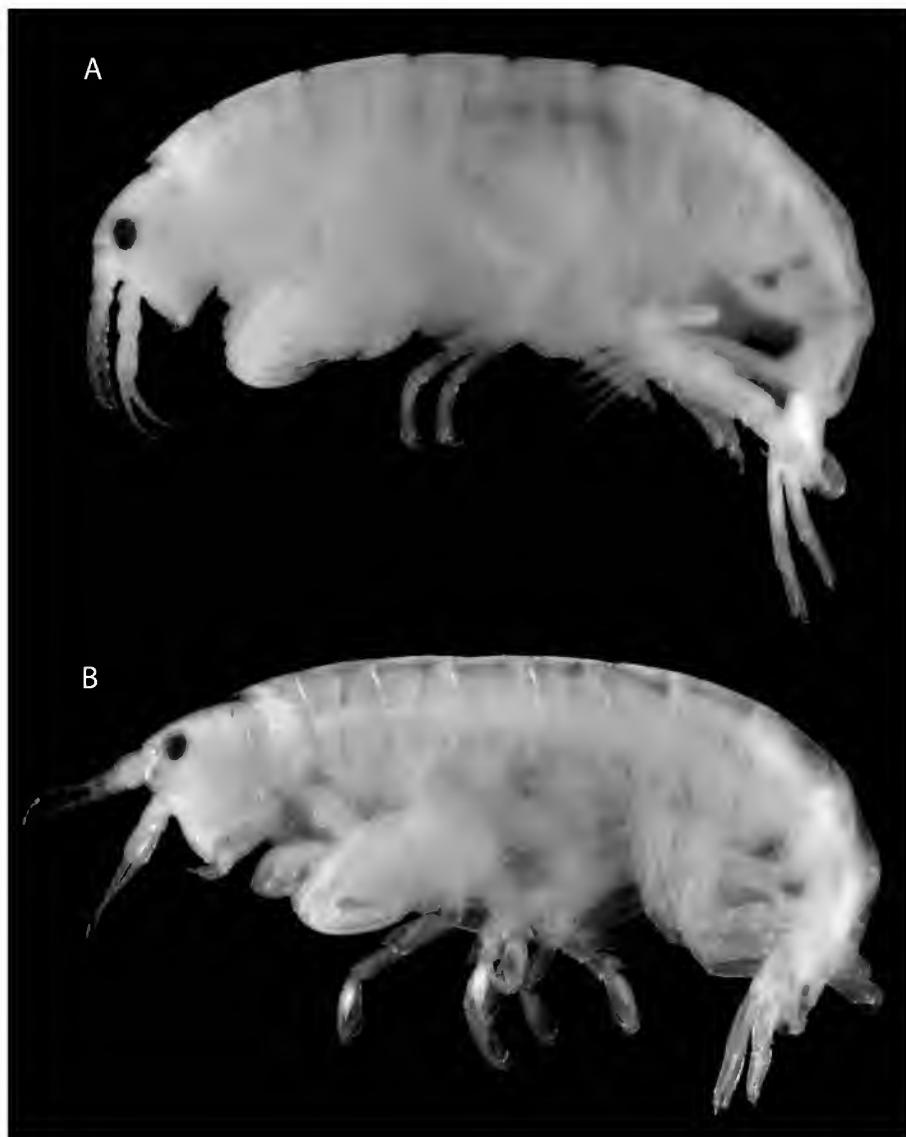


FIGURE 1. A. *Hyachelia tortugae*. AMNH 12533-10008-451, male 7.52 mm. B. *H. lowryi*. AMNH 12533-11008-002, male 4.86 mm.

collected from the buccal cavity of a green turtle, *Chelonia mydas* (Linnaeus, 1758), examined in the Galapagos Islands in the Pacific Ocean. *H. tortugae* has subsequently been reported sporadically from Hawai'i in the central Pacific Ocean (Balazs, 1980; Aguirre et al., 1998), occurring on the same host species. Among other characteristics that will be detailed below, *Hyachelia* can be easily distinguished from other hyalid genera by its elongate urosome and uropods one and two, and a radically reduced third uropod. (fig. 1). A second species, *Hyachelia lowryi* Serejo and Sittrop, 2009, was described as occurring not only on green turtles but also upon loggerhead turtles, *Caretta caretta* (Linnaeus, 1758) from Queensland, Australia. Additional specimens of both these species were obtained from material collected as part of

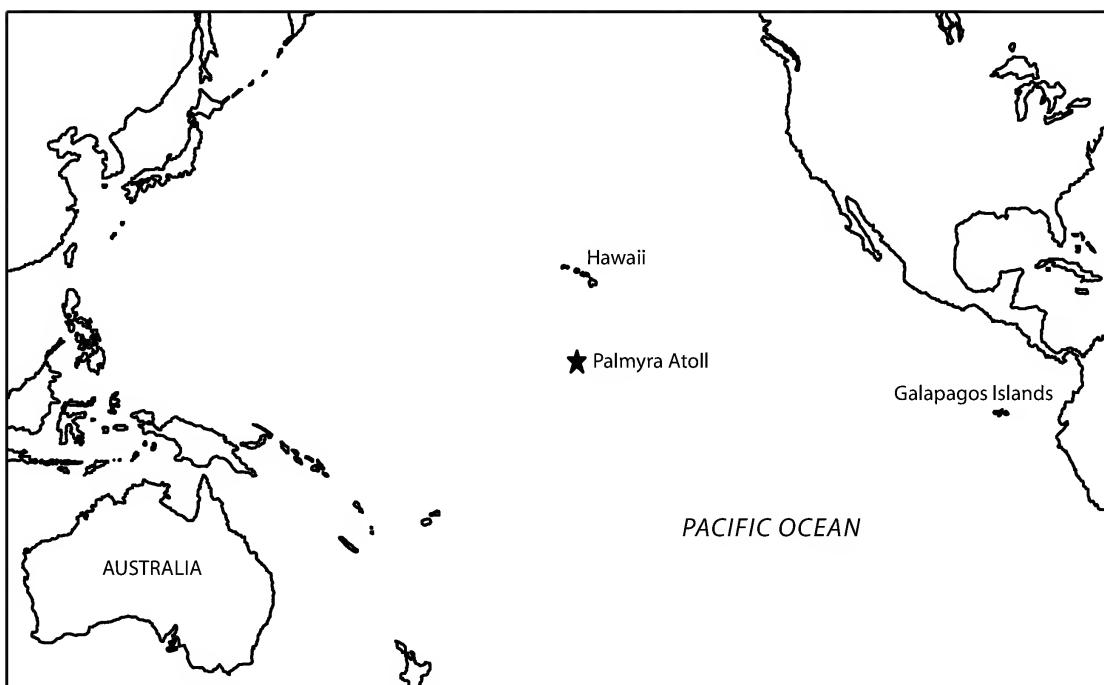


FIGURE 2. Map of Pacific Ocean showing location of Palmyra Atoll.

the American Museum of Natural History's Center for Biodiversity and Conservation (New York) survey of the epibionts living on Pacific green turtles foraging in the vicinity of Palmyra Atoll National Wildlife Refuge (PANWR) (2009–2011); these represent new distributional records of both *H. tortugae* and *H. lowryi* and only the second known occurrence of the latter. The amphipods obtained as part of the survey are reviewed and provided herein is a taxonomic commentary and species diagnosis that will allow for their better recognition.

METHODS AND MATERIALS

Palmyra Atoll National Wildlife Refuge (PANWR; fig. 2) is situated approximately halfway between the Hawaiian Islands and American Samoa in the Central Pacific Ocean ($5^{\circ}53' N$, $162^{\circ}5' W$). The atoll and 12 nautical miles of the surrounding ocean have been designated a marine protected area by the U.S. Fish and Wildlife Service since 2001 and the area forms part of the U.S. Pacific Remote Islands Marine National Monument established in 2009 (U.S. Fish and Wildlife Service, 2011).

Little is known about the ecology, behavior, biogeography, and conservation status of sea turtles in the central Pacific Ocean (Sterling et al., 2013). Since 2005 the Center for Biodiversity and Conservation from the American Museum of Natural History (New York) has been implementing a sea turtle research and conservation program at PANWR, with the primary goal of investigating the ecology, population biology, and conservation of green and hawksbill turtles on the atoll (Sterling et al., 2013). Turtles were captured using standard methods, and the epibiotic fauna of each animal was collected as part of a comprehensive physical evaluation.

Amphipods were preserved in 95% alcohol, stored in plastic vials, and subsequently brought to the Peabody Museum of Natural History, Yale University, for sorting and identification. The amphipod specimens were counted, categorized by sex and/or life stage, and selected individuals were isolated for dissection. Temporary and permanent microscope slide mounts were made of appendages from dissected individuals. Microphotographs were made from the appendages, and from these line drawings were generated digitally in Adobe[®] Illustrator[®] CS5 following the procedures described by Coleman (2003, 2009). All specimens are deposited in the collections of the Department of Invertebrate Zoology, American Museum of Natural History, New York.

SPECIMENS FIGURED

Hyachelia tortugae:

AMNH 12533-10008-451. Male, 7.52 mm. Palmyra Atoll, 19 July 2010; host: *Chelonia mydas*. AMNH 12533-11008-008. Male, 7.91 mm. Palmyra Atoll, 12 August 2011; host: *Chelonia mydas*. AMNH 12533-11008-057. Male, 7.98 mm. Palmyra Atoll, 12 August 2011; host: *Chelonia mydas*. AMNH 12533-08013-277. Female, 5.30 mm. Palmyra Atoll, 09 August 2011; host: *Chelonia mydas*.

Hyachelia lowryi:

AMNH 12533-11008-002. Male, 4.86 mm. Palmyra Atoll, 21 July 2011. Host: *Chelonia mydas*. AMNH 12533-11008-033. Male, 5.03 mm. Palmyra Atoll, 20 July 2010; host: *Chelonia mydas*. AMNH 12533-11008-111. Male, 5.23 mm. Palmyra Atoll, 12 August 2011; host: *Chelonia mydas*. AMNH 12533-11008-034. Male, 4.96 mm. Palmyra Atoll, 20 July 2011; host: *Chelonia mydas*.

RESULTS

During the three-year survey (2009–2011), a total of 170 green turtles and two hawksbill turtles were examined for epibionts. The total of both species of *Hyachelia*, i.e., *H. tortugae* and *H. lowryi* combined, was 580 specimens occurring on 50 individual host turtles (table 1). *Hyachelia* were found exclusively on green turtles; no epibionts were found on the hawksbill turtles. Both species of *Hyachelia* were found cooccurring on 11 (6%) of turtle hosts. Although the number of *H. tortugae* and *H. lowryi* was similar in the first two survey years (31 and 35 individuals respectively), in 2011 the samples were dominated by the latter: *H. lowryi* (68%, $n = 352$) as compared with *H. tortugae* (32%, $n = 163$). However, these numbers reflect only those specimens for which a positive identification could be made; a relatively large number of immatures and juveniles could not be identified to species. The number of specimens per turtle was not evenly distributed, ranging from a few individuals to as many as 73 *H. lowryi* and 29 *H. tortugae* from an individual host; most turtles had far fewer occurrences of either species. Although males and females of both species were found, ovigerous females were very rare among specimens of *H. tortugae*; only three were observed. By comparison, ovigerous females of *H. lowryi* were very common ($n = 105$).

Spatial distribution of *H. tortugae* revealed a strong positional bias; nearly 85% of the 2011 samples of *H. tortugae* were collected from the anterior region of the host (positional data were not recorded in 2009–2010). For *H. lowryi*, there was no obvious trend with about an even distribution on the anterior and posterior of the host.

TABLE 1. *Hyachelia* collected from green turtles at Palmyra Atoll, 2009–2011.

Year	Turtles with <i>Hyachelia</i> spp.	<i>H. tortugae</i>	<i>H. lowryi</i>	Total
2009	5	11	14	25
2010	10	20	21	41
2011	38	163	351	514
Total	53	194	386	580

There was a detectable association between the occurrence of *H. lowryi* and the presence of the platylepadid barnacle *Platylepas* sp.: nearly half of all *H. lowryi* were collected in the presence of this barnacle. A similar trend was not observed for *H. tortugae*; less than 5% were found cooccurring with *Platylepas* sp.

TAXONOMIC COMMENTARY AND SPECIES DIAGNOSIS

While superficially *H. tortugae* and *H. lowryi* appear very similar, they display important differences in key appendages. These appendages include the maxilliped, gnathopod 1, gnathopod 2, pereopod 6, and pereopod 7; pereopod 5 can also be diagnostic, but variably so. Further description of these appendages will provide guidance for species identification. These key differences make the question of cooccurrence on the same host individual more significant.

Hyachelia tortugae Barnard, 1967

Figures 3, 4, and 5A

Hyachelia tortugae is easily recognized based upon features of gnathopod 1 (males only) and pereopods 6 and 7. In males, article six of gnathopod 1 is very broad. The palm is sinuous and lined with stout robust setae. Additionally, four thick robust setae cover the posterodistal end of the sixth article. The dactyl is strikingly short, extending to only half the length of the palm. Gnathopod 2 (males), the palm is lined with robust setae and the proximoposterior corner protuberant. All the above characteristics can be seen through a microscope without dissection. However, the easiest way to recognize both males and females of this species is to examine the morphology of the sixth article of pereopods 6 and 7 (as well as pereopod 5, though this article is variable). If the distal margins of the sixth article of these pereopods are transverse, the specimen can be identified as *H. tortugae*; these margins are lobed and lined with grasping robust setae. Another distinct characteristic of *H. tortugae* is the shape of the uropods. The outer ramus of uropod 1 is broad and spatulate and its inner ramus is completely bare. The inner ramus of uropod 2 lacks setae, and is distinctly lanceolate.

Hyachelia lowryi Serejo and Sittrop, 2009

Figures 5B, 6, and 7

The presence of a whiplike seta on the distal segment of the maxilliped palp (males only) immediately distinguishes the specimen as *H. lowryi* (figs. 5B and 6). This whiplike seta on the maxilliped can be seen in lateral view of the head without dissection (figs. 1B and 5B). In many of the male specimens examined the large second gnathopods were seen “reversed,” or upside

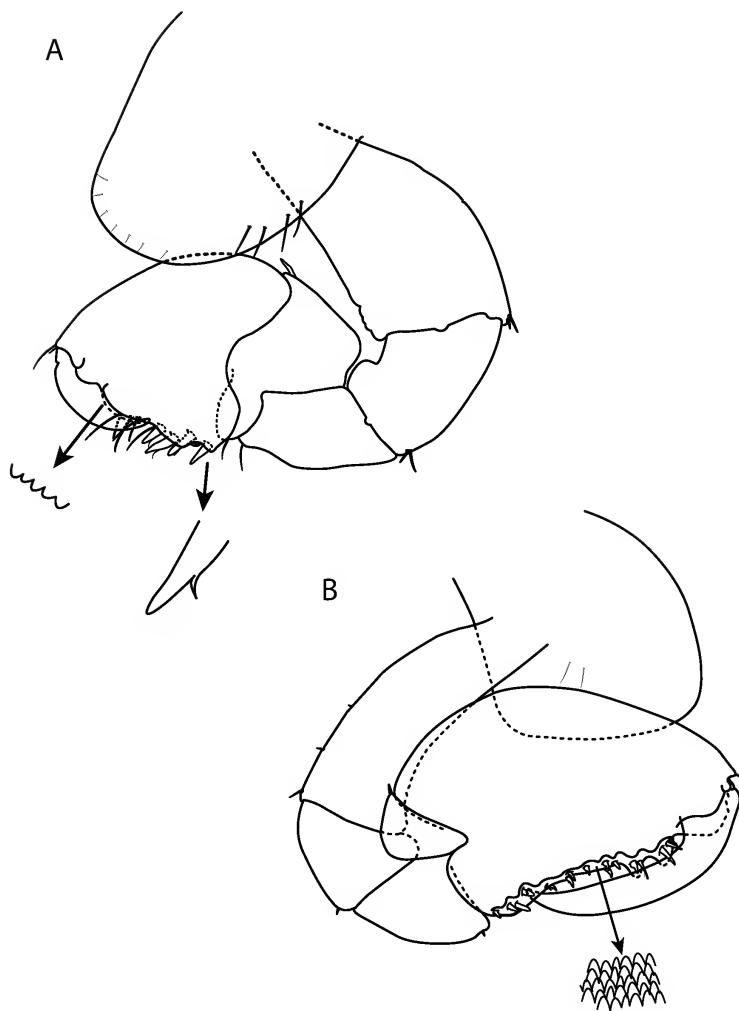


FIGURE 3. *Hyachelia tortugae*. AMNH 12533-11008-008, male 7.91 mm. A. Gnathopod 1 (outside lateral view). B. Gnathopod 2 (inside lateral view).

down, reflecting an essentially prehensile condition. Males and females of *H. lowryi* can be identified by their strongly oblique anterodistal margin of pereopods 6 and 7. These anterior distal margins are covered by seven falcate, robust setae. The morphology of the uropods in *H. lowryi* is consistent among males and females: both rami are lanceolate and their posterior margins are armed with robust setae (figs. 6D and 6E). Another notable feature limited to males is the broadly convex palm of the gnathopod 1; the anterodistal corner is weakly produced and covered with fine scales. The dactyl length equals that of the palm. In male gnathopod 2 the palm exceeds the length of the dactyl and the proximoposterior corner lacks robust setae.

When encountered together, adults of *H. tortugae* are generally much larger than *H. lowryi*. For example, males of *H. tortugae* are typically 7–8 mm and females are approximately 6–7 mm. Males of *H. lowryi* are smaller at about 4.5–5.0 mm in length, while females are typically around 4 mm. Although many of the aforementioned characteristics are useful in recognizing both species, the strong sexual dimorphism displayed in *H. tortugae* and *H. lowryi* limit several

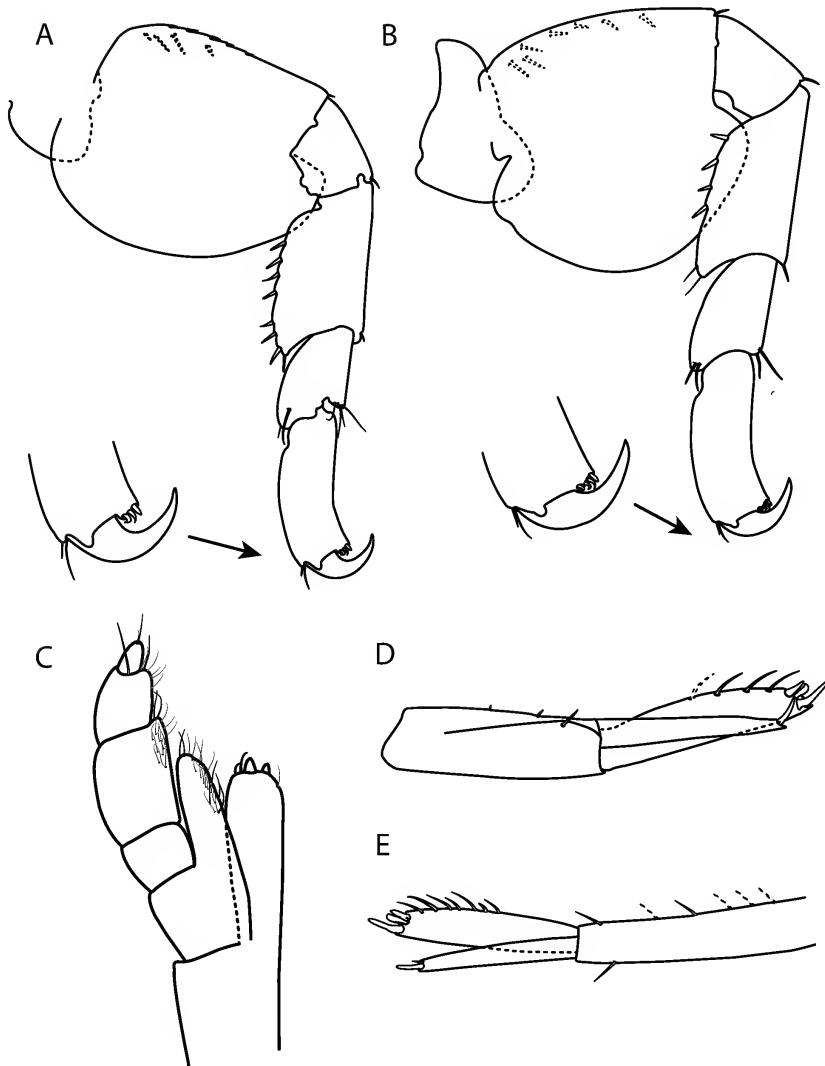


FIGURE 4. *Hyachelia tortugae*, AMNH 12533-11008-057, male 7.98 mm. A. Pereopod 6. B. Pereopod 7. C. Maxilliped. AMNH 12533-08013-277, female 5.30 mm. D. Uropod 1. E. Uropod 2.

of these characteristics to the males. Females of *H. lowryi* do not possess the whiplike seta of the maxilliped and neither female *Hyachelia* species exhibit distinctive gnathopods. However, the diagnostic characters of the pereopods are observable in all adult specimens. Furthermore, the robust setae in the anterodistal corner of the pereopods are not fully developed in very small juveniles of *H. tortugae*, and their distal margin may appear oblique.

SIMPLIFIED TAXONOMIC KEY TO THE SPECIES OF *HYACHELIA*

- 1a. Pereopods 6 and 7, anterodistal margin transverse; distal article (males) of maxilliped palp with truncate robust setae..... *lowryi*
- 1b. Pereopods 6 and 7, anterodistal margin oblique; distal article (males) of maxilliped palp with whiplike seta *tortugae*

DISCUSSION

Our report of both *Hyachelia tortugae* and *H. lowryi* from Palmyra Atoll represents a significant range extension from previously known occurrences. In particular, *H. lowryi* was previously known only from the type locality of Queensland, Australia; the new records represent a significant westerly extension of nearly 6000 kilometers. Although both species have been reported as epibionts from primarily Pacific green turtles, it is significant that they have been found living together on the same host individual. Given that these species have never been found independently from a turtle host, we can presume both *H. lowryi* and *H. tortugae* are obligate ectocommensals. Baldinger (2000) reported that the only other amphipod known exclusively from a marine turtle host is *Podocerus chelonophilus* (Chevreux and de Guerne, 1888). Although *Podocerus umigame* Yamato, 1992, has also been reported as an obligate epibiont amphipod, Baldinger (2000) has suggested that *P. umigame* is most likely a junior synonym of *P. chelonophilus*; this has been affirmed by Lazo-Wasem et al. (2011).

While the data are limited, the number of *Hyachelia tortugae* versus *H. lowryi* found in the samples from Palmyra Atoll provides insight into the population characteristics of both these epibionts. The number of *H. lowryi* specimens greatly outnumbered *H. tortugae* individuals almost two to one. Additionally, only three ovigerous *H. tortugae* specimens were found as compared to 105 ovigerous *H. lowryi*. The overwhelming presence of ovigerous *H. lowryi* specimens versus ovigerous *H. tortugae* specimens indicates that these two species apparently do not have a contemporaneous mating/brooding period. Furthermore, positional occurrence of *H. tortugae* as compared with *H. lowryi* points to a trend that the former reside predominantly (85% occurrence) at the anterior of the turtle, implying that many came from either the crop lavages or tissue folds surrounding the neck region. This would correlate with the original report of this species in the buccal cavity of a green turtle (Barnard, 1967) and subsequent reports (Balazs, 1980) of *Hyachelia* (as *H. tortugae*) from the same host species. It should be noted that another epibiont, the platylepadid turtle barnacle *Stomatolepas praegustator* Pilsbry, 1910, has also been found to inhabit the buccal cavity of marine turtles in a nonparasitic relationship.

Although spatial occurrence of *Hyachelia lowryi* on their host did not point to any particular trend, more than half of the specimens collected were found in association with a platylepadid barnacle, *Platylepas* sp. Many of these barnacles were covered in tufts of algae, and some of these tufts had *H. lowryi* adhering with their prehensile pereopods even after death and preservation. The importance of barnacles as substrate for algae-nestling invertebrates such as amphipods has been previously discussed (Lazo-Wasem et al., 2011).

Biogeographically, the currently known distribution of *Hyachelia tortugae* and *H. lowryi* in the Pacific Ocean is interesting. The former is previously known from the Galapagos Islands and the Hawaii Islands; reports on the latter species from Australia and now from Palmyra Atoll indicate a broad distribution of this genus in the Pacific. However, neither has been reported from turtles inhabiting the Pacific waters adjacent to the western coast of Mexico or elsewhere along the continental margin. Instead, the only obligate commensal amphipod of marine turtles reported from these coastal waters is *Podocerus chelonophilus* from Mexico (Hernández-Vásquez and Valadez-González, 1998; Gámez Vivaldo et al., 2006; Angulo-Lozano et al., 2007 [incorrectly as *Caprella*]; Lazo-Wasem et al., 2011).



FIGURE 5. A. *Hyachelia tortugae*. AMNH 12533-10008-451, male 7.52 mm. B. *H. lowryi*. AMNH 12533-11008-002, male 4.86 mm. Scale bars = 0.5 mm.

The available data suggests a distribution of *Hyachelia* spp. across the Pacific Ocean (Galapagos, Hawaii, Palmyra, and Australia) exclusive of western continental localities. Almost all Pacific Ocean records of *Hyachelia* have been from green turtles. In fact only a single record is reported from a different host, a loggerhead turtle (*Caretta caretta*) from Australia, which harbored several individuals of *H. lowryi* (Serejo and Sittrop, 2009). That the aforementioned epibiont studies have encountered primarily olive ridley turtles (green turtle sampling being very limited) may indicate that *Hyachelia* simply do not occur on olive ridleys and are essentially host-specific on green turtles. This may be further supported by the fact that olive ridleys are not devoid of all obligate commensal amphipods, given the routine occurrence of *Podocerus chelonophilus*.

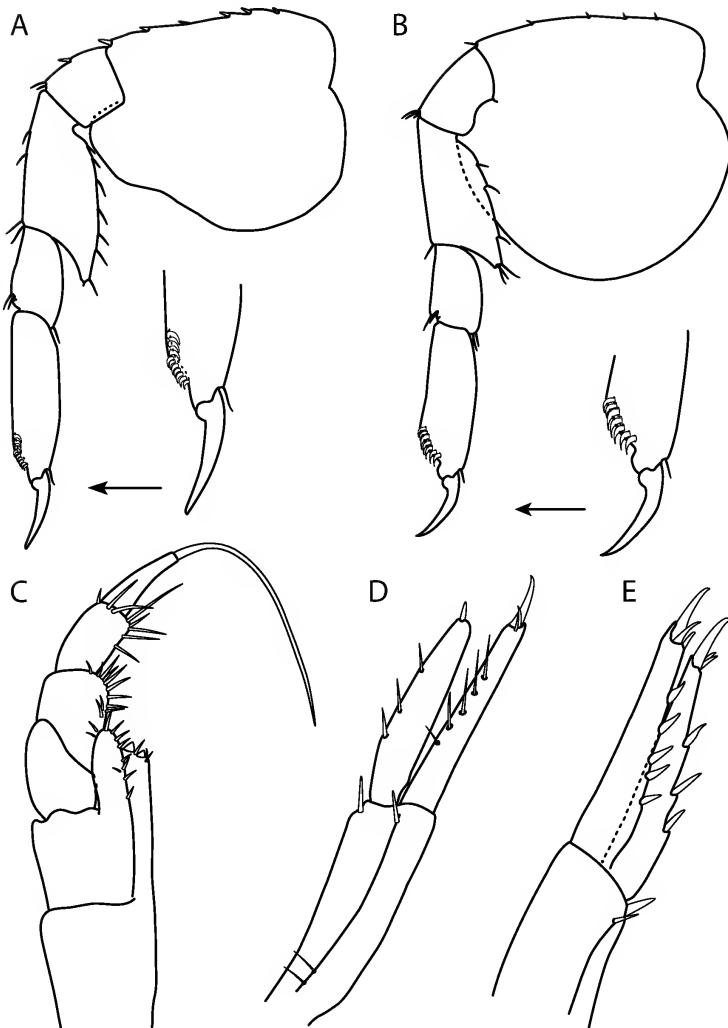


FIGURE 6. *Hyachelia lowryi*. AMNH 12533-11008-033, male 5.03 mm. A. Pereopod 6. B. Pereopod 7. AMNH 12533-11008-111, male 5.23 mm. C. Maxilliped. D. Uropod 1. E. Uropod 2.

Increased collecting of epibionts throughout the Pacific will undoubtedly fill in gaps of the distribution of *Hyachelia* spp. relative to geography and host occurrence. Furthermore, increased sampling may help to determine demographic and reproductive periodicity as well as potential host specificity. For example, if *Podocerus* and *Hyachelia* are ever found to co-occur, the lack of the latter on olive ridleys may be solely a function of host, rather than a result of geography or the presence of the former.

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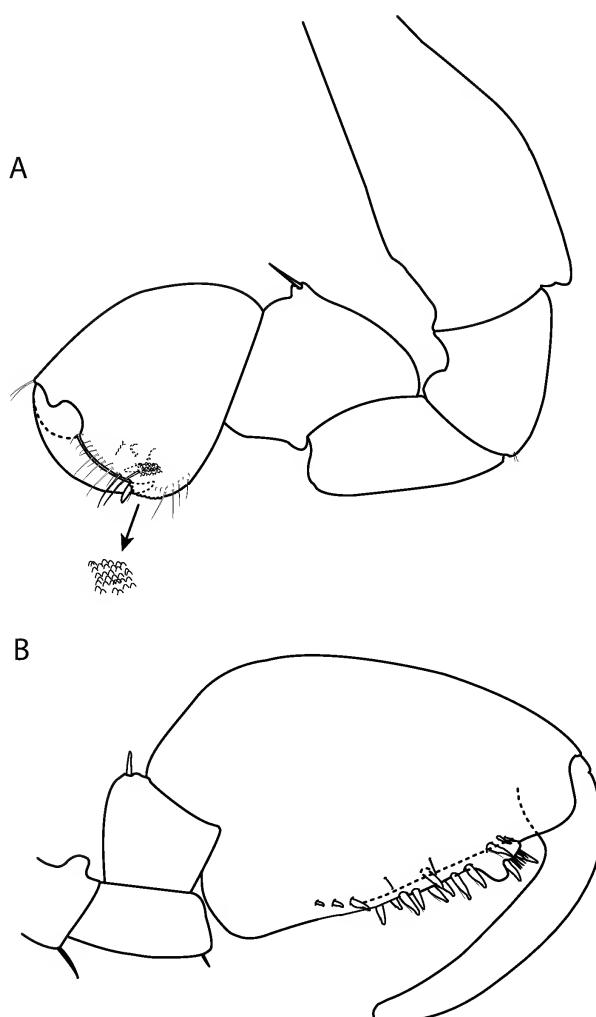


FIGURE 7. *Hyachelia lowryi*. AMNH 12533-11008-033, male 5.03 mm. A. Gnathopod 1 (inside lateral view). AMNH 12533-11008-034, male 4.96 mm. B. Gnathopod 2 (inside lateral view).

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